General information and recommendations regarding cleaning of breathing apparatus and breathing masks

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Contents

Soot and hazardous substances from fires are a health risk

Soot and smoke from fires can contain many types of hazardous substances including carcinogens, depending on what is burning and the conditions under which it burns (Karlsson and Quintiere 2000). Soot consists predominantly of organic particles and some particles can be very small and penetrate deep into the lungs and be absorbed into the body. Soot particles can contain hazardous chemicals which can be absorbed through the skin or the lungs. Several scientific studies have shown that long and/or repeated exposure to soot can give rise to various types of cancer and other diseases (Straif et al. 2007 (WHO), LeMasters et al. 2006, Bengtsson and Antonsson 1993).

Importance of protection against exposure to soot

It is important and necessary to minimise exposure to soot and hazardous substances in order to reduce health risks as much as possible. Protective measurements can include use of personal safety equipment, carefully considered working methods, good ventilation, control of air pollution in work areas, design of work areas with the contaminated side separated from the clean side, thorough cleaning of contaminated equipment, good personal hygiene, and education of personnel regarding health risks and safe handling of equipment.

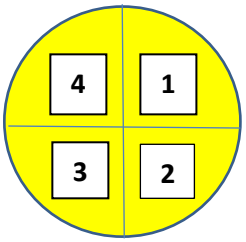
Soot contaminated surfaces can be difficult to clean

Soot is a type of contamination that binds onto certain types of plastic, rubbers and to painted or lacquered surfaces. It can be very difficult to remove without mechanical processing, for example with a brush or sponge, even when using the most powerful cleaning agents. Highly concentrated alkaline or solvent-based cleaning agents are not very effective, and often the soot-soiled material is damaged instead. It is particularly difficult to remove old and ingrained soot deposits, and deposits that are more or less burnt on.

Parameters which affect the cleaning result

The cleaning result is chiefly affected by four parameters:

1. Type and quantity of detergent (chemistry)
2. Washing temperature
3. Washing time
4. Mechanical processing



In general, these parameters can replace each other to a certain extent, but seldom completely. An effective detergent makes it possible to reduce the washing temperature and/or shorten the washing time and/or reduce the mechanical processing. Longer washing times often mean that a milder detergent can be used in smaller doses, and/or that the washing temperature can be lowered, and/or that less mechanical processing is required. A higher washing temperature and/or more vigorous mechanical processing will make a shorter washing time possible, with use of a milder detergent, etc. Since it is difficult to wash soot off from e.g. plastic surfaces without mechanical processing, e.g. with a brush or scouring sponge, it is necessary to maximise all the parameters which affect the cleaning result, such as time, temperature, rinsing pressure and the cleaning agent, but without damaging the materials of the breathing apparatus.

Choice of detergent

When choosing a detergent for cleaning, it is important that the detergent will effectively remove the relevant type of dirt and at the same time is safe on the material to be cleaned. It is also important to remember when choosing a detergent that it should be practical in use and not too hazardous for health or the environment or too flammable or corrosive to be stored and handled in a reasonably safe manner. With regard to water-based cleaning agents, pH neutral to alkaline agents are often most suitable for removing organic dirt such as oil, grease, fats, soot, proteins, starch, stains from wine, coffee and tea etc. while acidic agents are most effective for inorganic soiling, such as lime deposits, rust, metal oxides, metal hydroxides (verdigris) and salts. Solvent-based cleaning agents such as cold degreasing agents are normally most effective for dissolving and removing oils, fats, tar, asphalt, wax etc.

With regard to water-based cleaning agents in general, the more basic (alkaline) or acidic the agent is, the more effectively it will loosen up and remove dirt. However, if the agent is too strongly alkaline or acidic, it can damage the material to be cleaned, or damage the equipment that is used. As a product becomes more alkaline or acidic, it becomes more aggressive so it is important to consider, besides material safety, the safety of the user, and not to use stronger agents than absolutely necessary. Solvent-based degreasers and cleaners normally become increasingly effective as the content of aromatic hydrocarbons increases. At the same time, they become more hazardous to health and the environment and more aggressive to many materials such as plastic, rubber and painted or lacquered surfaces.

With regard to health and the environment, it is necessary to select products which are as safe as possible to use and which cause non or the least possible damage to the environment. To minimise the health risks from using detergents, it is advisable to avoid agents containing substances classified as highly poisonous, carcinogens, mutagens or liable to cause foetal damage, affect the reproductive system, cause allergies, or give off vapours or gases which are harmful to health during use, or which can be absorbed through the skin. It is also necessary to avoid unnecessary use of products classified as highly corrosive or corrosive to skin. In connection with the environment, the first choice should be products consisting of substances which are documented to be rapidly biodegradable (according to the OECD criteria), have sufficiently low ecotoxicity, are not bioaccumulated in the food chain and are based, as much as possible, on renewable raw materials which do not contribute to the emission of fossil carbon dioxide.

Some requirements which can be made for detergents:

1. They must clean effectively
2. They must be safe for the material to be cleaned
3. They must be safe for users
4. Environment friendly
5. Low cost in use
6. Stability during storage
7. They must be easy and safe to use

Detergents and cleaning methods – are always a compromise between different needs and requirements

Choice of cleaning method and cleaning equipment

When selecting the method and equipment, e.g. for cleaning breathing apparatus it is important to weigh the cleaning effect against the risk of damage to the materials and the risk of damage to health and the environment. If the temperature is too high, or the mechanical processing too vigorous, or the water pressure is too high (in high-pressure washers), or the soaking or washing cycle takes too long, various types of damage can be caused to different types of materials.

What to consider when selecting a detergent and cleaning method:

a. The kind of dirt to be cleaned away
b. The type of materials (type of items to be washed) from which the dirt is to be removed
c. The degree of soiling to be removed
d. The desired cleaning result (how clean is sufficiently or acceptably clean?)
e. Possibilities for cleaning (rooms, electricity, water, drainage, personnel, washing equipment, time, etc.)
f. The work environment
g. The external environment
h. Costs (personnel, working hours, water, energy, detergents, investments, etc.)
i. Reliability of delivery, quality, service, availability, official requirements, approvals, etc.

Cleaning of breathing apparatus in PPE dishwashers

Fire-fighters are exposed to the smoke and soot from fires in the course of their work and both protective clothing and breathing apparatus become soiled with soot and hazardous substances. To reduce exposure to soot and hazardous substances it is necessary to handle contaminated clothing and breathing apparatus in a way that minimises skin contact and inhalation throughout the processing chain. It is also important that employees responsible for cleaning protective clothing and breathing apparatus are not exposed to soot and hazardous substances during the cleaning process.

In order to make cleaning easier and more safe special cleaning equipment has been developed in recent years in form of PPE dishwashers. These machines are ordinary dishwashers for professional use that have been modified for cleaning of breathing apparatus. Instead of tableware, entire sets of breathing apparatus or parts of them are placed in the machines to be cleaned. Most of the machines are the type known as tank dishwashers and function in the same way. A tank dishwasher has a tank with cleaning water, which varies in size from about 25 litres to 150 litres, depending on machine size. The tank is filled with water and detergent which is used for cleaning. The cleaning water is replaced slowly in the tank when the items to be cleaned are rinsed with 5-10 litres of clean water. There are also PPE dishwashers of fresh-water type. These machines use new, clean water for every new wash. Both types of PPE dishwasher have built-in electronic controls on which settings can be selected to regulate the washing process automatically. Note that the washing result is determined by the type and amount of the detergent, total washing time, washing temperature, water pressure, the positioning of the spraying nozzles in the PPE dishwasher in relation to breathing apparatus to be cleaned.

Cleaning process in PPE dishwasher of water tank type

1. The water tank in the PPE dishwasher is filled with water (about 25 - 150 litres depending on machine size)
2. The water is heated up to about 55° C - max 60° C
3. The detergent is dosed automatically in the water tank
4. The breathing apparatus to be cleaned are placed in the machine
5. The cleaning cycle starts, and normally lasts for about 3-12 minutes (different times can be set). (Note: The longer the washing times 20-30 minutes gives better cleaning results)
6. After cleaning the breathing apparatus is rinsed (sprayed) with about 5-20 litres of clean hot water (55° C – max 60° C)
7. 5-20 litres of washing water run out of the machine into the drain and are replaced by the rinsing water
8. Extra detergent is dosed into the water tank to compensate for the dilution
9. The washing cycle is completed and the breathing apparatus can be taken out of the machine
10. The machine is ready for the next wash
11. The washing water should be replaced and the machine cleaned at least three times a week, or at the latest after 5-10 washes, depending on the degree of soiling of the breathing apparatus to be washed.

Cleaning process in a PPE dishwasher of freshwater type

1. The breathing apparatus to be cleaned are placed in the machine
2. The machine starts
3. The dishwasher tank is filled with water (about 20 - 50 litres depending on machine size)
4. The water is heated to the set temperature (55° C – max 60° C)
5. Detergents are automatically dosed into the water tank
6. The breathing apparatus is cleaned and rinsed through several steps according to the set washing program
7. Total cleaning time depends on program selected, normally 25 - 60 minutes
8. After the final rinsing in one or several steps the cleaning process is completed
9. After that the cleaning and rinsing process is finished all water in the machine is emptied in the drain

An important difference between a PPE dishwasher of tank dishwasher type and PPE dishwasher of fresh-water type is that in the fresh-water machine the tank water is replaced for each new set of breathing apparatus to be cleaned and sometimes even several times during the same cleaning process. This means that in a PPE dishwasher of fresh-water type soot and other dirt does not accumulate in the washing water from one washing cycle to the next. Since a PPE dishwasher of the fresh-water type uses clean water for every new wash, there is no need to replace the water and there is less need for internal cleaning of the machine compared with PPE dishwasher of tank dishwasher type.

Detergents for cleaning breathing apparatus

Breathing apparatus are made of several different types of materials such as plastic, various types of rubber, composites and metals such as stainless steel, brass and aluminium. Some surfaces also have surface treatments or are painted or lacquered. There are many seals, packings and membranes built into the equipment. Several of the materials may be sensitive to certain types of chemicals (cleaning substances) and may be damaged if the wrong types of detergents are used. Normally the most sensitive materials are the same in different brands of breathing apparatus and in general it is advisable to avoid strongly alkaline substances with few exceptions (pH above 10,5), acidic substances (pH below 7) and cleaning agents which contain organic solvents such as petrochemical solvents (cold degreasing agents), alcohols, glycol ethers, acetone, ethyl acetates etc. Sometimes the material damage only appears after several months or years of cleaning.

To reduce the risk of material damage during cleaning, it is important only to use cleaning agents and cleaning methods which are approved or recommended by the manufacturers of the breathing apparatus and breathing masks.

Factors which affect the cleaning results in PPE dishwashers

1. Type of detergent
2. Dosage (content of cleaning agent in the washing water)
3. Washing temperature
4. Washing time
5. Mechanical processing (spraying with water at high pressure)
6. The sequence of the washing process (washing stages and rinsing stages)
7. Machine hygiene (replacement of water and cleaning the washing installations)
8. The positioning of the items to be cleaned in the machine (in the washing chamber in relation to the spray nozzles)

Detergents

The detergents for cleaning of breathing apparatus should be selected according to the recommendations of the breathing apparatus manufacturer. These detergents are often carefully tested for cleaning effectiveness and material safety. In order to clean soot effectively from plastics, rubber and lacquered or painted surfaces it is necessary to use detergents that produces very low surface tension in the washing water and is an effective pigment/particle (soot) dispersant. For cleaning of breathing apparatus in PPE dishwashers it is very important to use only low foaming detergents.

Dosage

The optimal dose is often indicated in the product information from the detergent manufacturer. For cleaning breathing apparatus in PPE dishwashers the recommended dose is normally between 1 % and 3 %, depending on the detergent, the number of washes (in a tank dishwasher) and the degree of soiling and also the washing time and temperature. Overdosing only improves washing results marginally or not at all, but it increases costs and the environmental impact. Note that dosing is much higher for cleaning of breathing apparatus compared with the dosage for ordinary detergents used for machine dishwash at restaurants and kitchens.

Cleaning temperature in PPE dishwashers

The cleaning temperature is usually a compromise between different functions and requirements. The cleaning effect normally increases as a function of increasing cleaning temperatures. Oils and fats, for instance, become more free-flowing at higher temperature and therefore are easier to remove. Cleaning and washing-up agents for dishwashers often require a temperature above 50° C or higher to prevent foaming. Below 50° C there is a considerable risk of foaming. In practice this means that the lower temperature limit is 50° C. The upper limit for the temperature is often determined by what the materials can withstand. Tests have shown that there is a considerable risk of material damage, especially on breathing masks if they are washed at temperatures above 60° C. Most PPE Washers in Sweden and Norway are configured to clean and rinse at 58° C - 60° C.

Cleaning time

Cleaning time is also a compromise. The longer the cleaning time is, the better the cleaning result will be but sometimes it is necessary to complete a large number of washes in a short period of time. The washing effect increases most in beginning of the cleaning process up to some 20 - 30 minutes and then levels out more and more. Most PPE dishwashers on the market in Sweden and Norway have until now been configured for a relatively short washing time, between 3 and 12 minutes. The cleaning results that has been obtained with these short washing times can be regarded as a pre-wash or preliminary cleaning, which normally call for further manual cleaning by hand. If the cleaning time is increased to 20 – 30 minutes much better cleaning results can be obtained.

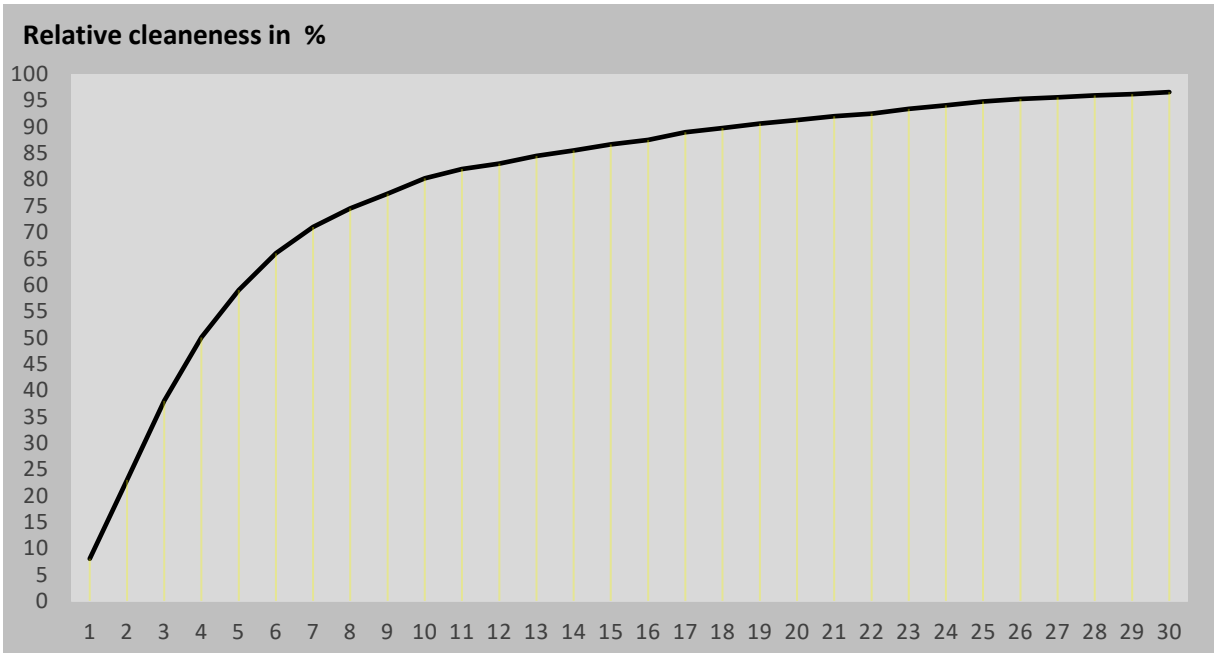


Diagram No 1. Cleaning effect as function of time when cleaning in a PPE dishwasher. The cleaning effect increases most rapidly during the first minutes, and then levels out more and more as time passes. Besides time required for cleaning, the cleaning effect (the appearance of the curve) is affected by the type and concentration of the cleaning agent, the temperature, and the mechanical cleaning effect of the washing water and the rinse-water streams/beams in the machine.

Improving cleaning results with longer cleaning times and pre-treatment

By increasing the cleaning time to 20-30 minutes, e.g. by using a longer cleaning program or by repeating the washing process, an appreciably better washing result can be achieved. The washing result can be further improved if the cleaning agent is sprayed onto the items to be washed a few minutes before washing. An effective pre-treatment is to wipe the breathing apparatus quickly with a soft washing sponge soaked in with cleaning agent just before cleaning in a PPE dishwasher. Note that it is important to follow the breathing apparatus manufacturers' recommendations regarding type of cleaners to be used, maximum cleaning temperatures etc.

Mechanical processing

What type of mechanical processing of soiled surfaces will occur in a PPE dishwasher, and thus how much it can contribute to the effect, is mainly determined by the quantity of water, the water pressure during cleaning and rinsing, the positioning of the spray nozzles in relation to the breathing apparatus being washed and the design of the washing chamber. The greater the water pressure is and the larger the quantity of water is, and the closer the items being washed are to the nozzles, the greater the mechanical cleaning effect will be. The water pressure limit is set by what the materials can withstand and by the capacity of the PPE Dishwasher. The position of the rinsing nozzles in relation to the breathing apparatus being cleaned is of great importance for the cleaning effect. If the beams of water spray cannot reach the surfaces to be cleaned, the cleaning effect is noticeably reduced and so-called shadows of soiling remain on the washed items. In this connection the positioning of the items to be washed is very important.

Washing cycles and rinsing cycles

Different manufacturers of PPE dishwashers distribute the washing and rinsing cycles in different ways, with varying numbers of washing and rinsing cycles, and their timing varies, depending on the type of machine and what is to be washed. The PPE dishwashers are often pre-programmed with several cleaning programs from few minutes up to 30 minutes or more. A shorter program can be used for cleaning lightly soiled items, and a longer program for more heavily soiled items.

Picture 1. Contaminated part of a breathing Apparatus.

Picture 2. Same part as in picture no. 1 After cleaning in PPE dishwasher.

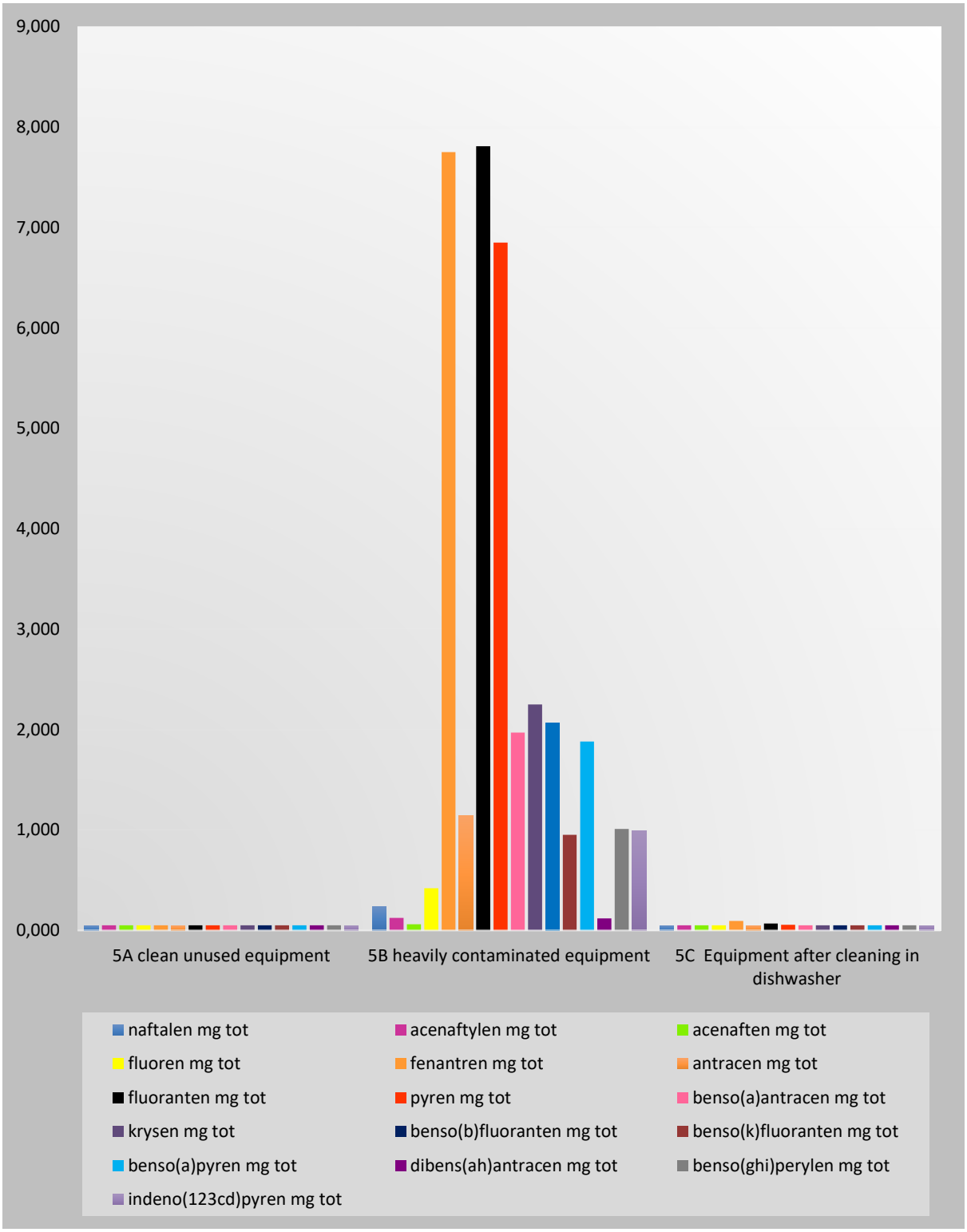


Diagram No 2. With pre-treatment and cleaning in PPE Dishwasher during 20 minutes at 60^{o} C with Lejon Kemi FFE Cleaner and Lejon Kemi SRP Defoamer it is possible to achieve very good cleaning results on breathing apparatus. Total levels of 16 hazardous and carcinogenic substances (PAH) where analysed by an independent laboratory from new, unused breathing apparatus, from heavily soot-contaminated breathing apparatus and from pre-treated and washed breathing apparatus. **Note** that the total content of the 16 different PAH on new, unused breathing apparatus and on cleaned breathing apparatus is below the detection limit of 0.050 mg for the method of analysis used, with the exception of a few values, which were close above the detection limit.

Machine hygiene

To achieve the best possible cleaning result it is very important to replace the washing water (preferably daily) in PPE dishwashers of tank model and to clean the inside of the cleaning tank carefully. Even after a few washes, soot and other hazardous substances will accumulate in the cleaning water and in the water tank and affect the cleaning result. It is therefore necessary to replace the cleaning water and clean regularly, not only to remove soot particles and other health-hazardous substances but also to prevent the growth of microorganisms like bacteria and fungus etc. The availability of water (hose with a rinsing nozzle) and suitable cleaning tools make it considerably easier to clean the inside of the PPE dishwashers.

Picture 3. Cleaning water inside a PPE dishwasher contaminated with soot, dirt and hazardous substances after cleaning of breathing apparatus.

Foaming problems

Picture 4. Residues of foaming detergents in carrying harnesses may give rise to heavy foaming when they are cleaned in PPE dishwasher.

Detergents which have been developed for washing breathing apparatus in PPE dishwashers with high-pressure rinses produce practically no foam at washing temperatures of 50^{o} C or above. However, extensive foaming may occasionally occur and cause problems in PPE dishwashers. The problem is usually caused by residues of foaming detergents which may have been used earlier for cleaning the breathing apparatus manually. Residues of foaming detergents are often found in straps and padded carrying harnesses. Extensive foam build-ups can also be caused by residues of fire-extinguishing foam. Extremely small amounts of foaming detergents or fire-extinguishing foam are sufficient to cause problems with foaming. Some types of soot from fires can also cause foaming if soot is accumulated in the cleaning water. In this connection it is important, if possible, to rinse out residues of foaming substances before using the PPE dishwasher for cleaning and not to use foaming detergents or wipes at any stage of cleaning. Foaming can also be caused if the temperature in the machine is too low. Heavy foam formation in the machine may result in far less effective cleaning and the foam may overflow from the machine causing unnecessary extra work to clean up floors etc. from foam. Sometimes it takes a long time to solve the foaming problem and it may be necessary to add an anti-foaming agent in the washing tank to keep foaming under control. It is however important to eliminate the causes of heavy foaming.

Cleaning of breathing masks

When breathing apparatus and carrying harnesses are cleaned together with breathing masks in PPE dishwasher soot, dirt and hazardous substances are released into the washing water. These contaminants will come in contact with the insides of the breathing masks and If the breathing masks are not rinsed very carefully by hand after washing there is a great risk that sooty and dirty washing water will remain in the inside of the breathing masks and form deposits close to the respiratory tract and come into contact with skin. To avoid this, it is recommended that breathing masks should be washed separately, either manually or in a washing machine.

Pictures 5 and 6. Soot and dirt deposits on the insides of breathing masks after cleaning in a PPE dishwasher and not been rinsed manually after cleaning on the inside.

Washing breathing masks in a washing machine

An alternative for manual cleaning by hand of breathing masks is to wash them in a washing machine. This is possible if the breathing masks are placed inside specially designed washing bags and washed with a detergent and program developed for the purpose. This method gives excellent cleaning results according to independent laboratory tests and no manual rinsing is required afterwards. It is possible to wash up to 12-14 breathing masks at the same time in large washing machines which makes the method practical to use for fire brigades.

Picture 7. Sooty breathing masks before machine wash.

Picture 8. Breathing masks from Picture 7 after machine washing.

Investment in PPE dishwashers and washing machines

When investing in automatic washing installations for cleaning breathing apparatus and breathing masks, it is important to bear in mind that the cleaning result that can be achieved always will depend on the **machine design, type of detergent, dosing of detergent, cleaning temperature, total washing time, rinsing** and on **good hygiene in the machine**. The PPE dishwasher and washing machines form an entity together with the detergents and washing parameters (see page 2). It is no use having an excellent machine without the right type of detergent in the right concentration, or if the washing parameters are not correctly configured.

What to consider when choosing washing installations for cleaning breathing apparatus

1. The required result of cleaning
2. The cleaning effect that can be achieved depends on the machine, cleaning agent, dosing, the structure of the washing process, total washing time and temperature, and good hygiene in the machine.
3. The types of items to be washed (entire breathing apparatuses, air cylinders, carrying harnesses, or only breathing masks).
4. Washing frequency (how much and how often the machine will be used)
5. Ergonomics at work (including lifting items to be washed in and out of the machine)
6. Power consumption (including heating the water)
7. Water consumption per wash
8. Time required for filling and heating the water tank in PPE dishwashers
9. Setting options (washing times, temperatures, dosing, rinsing etc.)
10. User-friendliness
11. Risk of incorrect settings (e.g. too easy to alter washing parameters by mistake)
12. Ease of cleaning the machines
13. Requirements for barrier dishwashers and barrier washing machines in order to make it possible to have a contaminated side and clean side of the area at fire station for handling of contaminated and cleaned equipment.
14. Consumption of detergents
15. Price (purchase, leasing, hire, hire-purchase)
16. Service (maintenance and repairs)
17. Guarantees

PPE dishwashers and washing machines on the market that are suitable for cleaning of breathing apparatus and breathing masks are made by few well-established large companies such as Electrolux Professional, Miele Professional, Wexsiö disk (Ali group), Recue Intellitech and Podab. PPE dishwashers are available in different sizes and designs, but can be roughly divided into two main groups: tank dishwashers and fresh-water dishwashers. Information about the PPE dishwashers and washing machines available from the individual manufacturers. Which machine is most suitable depends to a large extent on the needs and requirements from the fire brigades.

Note! It is important that the PPE dishwashers and washing machines are professionally installed, and that program settings regarding dosing of detergent, cleaning temperature, cleaning time, rinsing etc. are correctly configured.

Dosing pumps for detergents

Some of the PPE dishwashers on the market have built-in dosing pumps and electronic controls for dosing detergents. Since the PPE dishwashers based on ordinary dishwashers intended for use in restaurants kitchens the built-in dosing pumps in some cases do not have the necessary capacity for the higher dosing required for detergents that have been specially developed for cleaning of breathing apparatus. It is usually quite simple to change to a larger pump with a higher capacity. Some PPE dishwashers are not equipped with a dosing pump at all and it is necessary to install separate external dosing pumps. Experience shows that timer-operated dosing pumps are preferable to conductivity-controlled pumps. Dosing pumps that are conductivity-controlled are more sensitive to irregularities and more difficult to adjust to give the correct dose. The cost of dosing pump and installation is relatively small in relation to the cost for a PPE dishwasher. It is important that the installation of the dosing pump and adjustment of dosing is carried out professionally.

Requirements for dosing pump

1. Capacity (it is important that the pump has sufficient capacity for correct dosing)
2. Timer-controlled dosing
3. Compatibility with the PPE dishwasher (electronics, software, power supply etc.)
4. Tolerance of chemicals/detergents
5. Space to install the dosing pump in the PPE Washer or outside it
6. Availability of service (maintenance) and repairs on site.
7. Quality
8. Price

Washroom for cleaning of breathing apparatus

When PPE dishwashers are installed for cleaning of breathing apparatus it is important to adapt the room where the machine will operate so it is as practical and functional as possible. It is also important to arrange the spaces and washing processes in such a way that the personnel who handle the cleaning are exposed as little as possible for contaminated equipment. It is also important to prevent soot particles and hazardous substances to spread to other areas of the fire station from the cleaning area and from transport of contaminated breathing apparatus and other equipment.

Some requirements for a washing room

1. Availability of hot and cold water
2. Availability of a power supply (sufficient voltage and current strength)
3. A waterproof floor with drainage that is easy to clean
4. Good lighting
5. Good ventilation (especially around the PPE dishwasher, as vapours and aerosols from the machine will escape into the room when it is opened after cleaning)
6. Access to workbenches and unloading surfaces where it is possible to load and unload the machine easily and ergonomically
7. Easy access and equipment for cleaning the inside of the machine
8. Consider the position of the room with regards to the flow of dirty and sooty items to be washed
9. Protective gloves, respiratory protection, protective goggles and eye douche must be available

Costs of using PPE Dishwashers for cleaning of breathing apparatus

The costs for cleaning of breathing apparatus in PPE dishwashers will depend on:

1. The purchase price of the machine (depreciation, capital costs (interest) etc.)
2. Installation costs
3. Energy consumption
4. Water consumption
5. Costs of the detergent
6. Time consumed per wash including handling before and after washing (personnel costs)
7. Time consumed filling and heating the washing-water
8. Time consumed emptying the machine (replacing washing water) and cleaning the machine (personnel costs)
9. Costs of service and any necessary repairs
10. Number of washes (per day, per changes of water, per month, per year)
11. Number of breathing apparatuses per wash

The detergents developed specially for cleaning breathing apparatus are generally more expensive than conventional machine washing-up detergents. However, the extra cost must be considered against the fact that the special cleaners do not damage the materials of the breathing apparatus and they are often significantly more effective. Some detergents contain special additives which bind and disperse the soot particles in the washing water. Compared with the total machine cleaning costs per breathing apparatus, the cost of the detergent is very small, only a few per cent.

To keep costs down, it is important to plan the washing, not to overdose, not to leave the water tank heater on unnecessarily, to keep the inside of the machine clean, and to carry out the necessary maintenance etc.

Cleaning costs of equipment from soot and other hazardous substances are negligible compared to the costs to society from diseases caused by soot, including cancer, not to mention the personal suffering of those affected and their relatives. Investment and operating costs of machine cleaning of breathing apparatus are very small compared with the other costs for operating a fire station.

Some suppliers of PPE Dishwasher and washing machines in Sweden

The following manufacturers and suppliers of PPE dishwashers have all supplied a number of installations to fire brigades in Sweden and Norway and several other countries.

Electrolux Professional AB

Karbingatan 18
254 67 Helsingborg, Sweden

Tel. +46 (0)372 – 665 01 (head office)

Rescue Intellitech

Jägershillsgatan 26
213 75 Malmö, Sweden

Per Liberg. Tel. + 46 (0)40 671 83 00 or + 46 (0)70 671 50 68

Miele AB (Professional)

Industrivägen 20
Box 1397
171 27 Solna, Sweden

Contact: Johan Lindberg. e-mail: professional@miele.se
Tel. + 46 (0)8 562 29 400 (exchange)

Wexiödisk AB

Mårdsvägen 4
352 45 Växjö, Sweden

Contact: Ulrik Svanberg. Tel. 0470 – 77 12 00 or 0709 – 16 15 01
e-mail: ulrik.svanberg@wexiodisk.com

Summary

According to several medical scientific studies, soot and other hazardous substances from fires can cause serious illness, including cancer, through long-term or repeated exposure, primarily though the skin and by inhalation and the fire brigade personnel is suffering from cancer more frequently than the population in general. To minimise the risks of exposure through inhalation and skin contact, it is necessary to have a carefully considered overall approach for safe handling and cleaning of contaminated equipment, from the site of the fire to the fire station and inside the fire station until the equipment has been cleaned. This includes, among other things, transport of contaminated equipment, planning and fitting out premises, ventilation, cleaning methods and cleaning equipment, personal safety equipment and education and instructing employees about risks, processes and how to handle contaminated equipment.

Soot and some other hazardous substances bind to certain plastics and rubbers and to surfaces that are painted or lacquered which makes it difficult to clean breathing apparatus and other equipment safely and effectively without damaging any of the materials they are made of. The cleaning results that can be achieved will always depend on the type of cleaning agent (chemistry), cleaning temperature, cleaning time and mechanical processing.

For some years there have been so-called PPE dishwashers on the market of different brands. These machines are based on ordinary dishwasher for professional use which are modified for cleaning breathing apparatus. When a PPE dishwasher is used for cleaning, the dosing of detergent, cleaning time, cleaning temperature and the water pressure are controlled by the machine's washing program and construction. Many conventional machine dishwashing detergents, degreasers and washing agents can damage the materials of breathing apparatus and breathing masks. High cleaning temperatures and high water pressure during cleaning and rinsing can also cause damage to materials. These limitations make it complicated and difficult to obtain good cleaning results of soot contaminated breathing apparatus in PPE dishwashers without causing material damage.

Until now, washing-up times have normally been short, 3-10 minutes, followed by rinsing with only 6-12 litres of clean water. Cleaning in PPE dishwashers has been considered as a form of rough cleaning or preliminary cleaning to remove loose particles of soot and other dirt from breathing apparatus and breathing masks. Poor cleaning results have often requiered manual cleaning and rinsing after washing up in PPE dishwashers in order to achieve an acceptable cleaning result.

After several years of product development and tests Lejon Kemi was able in 2018 to launched new detergents and new longer and improved cleaning programs for PPE dishwashers and an alternative to clean breathing masks in PPE dishwashers where the masks are placed in protective washing bags and washed by a specially developed detergent and program in washing machines. Analysis from external independent laboratories and practical use at several fire brigades in Sweden and Norway during long time shows excellent cleaning results for these new cleaning products and programs developed by Lejon Kemi.

The investments and costs for handling and cleaning of contaminated equipment at fire brigades are negligible compared to the costs to society for health care of fire fighters who have become ill i.e. cancer through exposure to soot and hazardous substances at work, apart from the suffering of patients and their families.

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Lejon Kemi AB

Lejon Kemi is a Swedish company specialised in surface- and cleaning chemistry.
The company has more than 30 years of experience of developing and manufacturing of environmentally adapted degreasing and cleaning chemicals for professional users and for private consumers. Lejon Kemi works within a network of large companies and partners who produce, market and sell products developed by Lejon Kemi.

Since 2011 Lejon Kemi has been developing cleaning agents and cleaning methods for washing breathing apparatus from soot and other hazardous substances manually and in PPE dishwashers and washing machines. The product development has been carried out in collaboration with several manufacturers of breathing apparatus, fire brigades, external laboratories, chemists, toxicologists and manufacturers of PPE dishwashers and washing machines.

Based on the knowledge and experience of development of detergents for cleaning breathing apparatus and breathing masks, Lejon Kemi has also developed a full range of cleaning chemicals for fire brigades e.g. for cleaning of protective clothing, helmets, fire hoses, vehicles, tools, machines, workbenches etc.

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